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(54) **Tilt control system for railway vehicles**

Neigungssteuerungssystem für Schienenfahrzeuge

Système de commande de l'inclinaison pour véhicules ferroviaires

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Description

Field of the Invention

[0001] The present invention is related to the adaptation of railway vehicles to improve the traveling conditions thereof, proposing a system which allows improving the dynamic behavior of said vehicles while traveling over curves, by means of controlling and regulating the rolling.

State of the Art

[0002] The first cause of limitation of the speed of trains when they travel over curves is the lateral force affecting the passenger as a result of the inertia that is not compensated by the banking of the track.

[0003] To eliminate this effect, railway vehicles are usually structured with a tilting arrangement of the body of the vehicle with respect to the bogie including the running gear, establishing systems which attempt to incline the body of the vehicle towards the inside of curves, i.e., in a direction opposite to the natural inclination due to inertia, thus generating a dynamic effect of banking of the track.

[0004] To obtain this inclination of railway vehicles towards the inside of curves, passive tilting systems and active tilting systems are known, the simplest method being that of passive tilting or natural pendulation, consisting of arranging the axis of rotation of the suspension above the center of gravity of the body of the vehicle. With this method, since the tilting axis of rotation has to be arranged high up, it is necessary to make a design of the body with very small dimensions at the lower part, in order to not have gauge problems, requiring a complex design of the bogie and of the body, with the subsequent cost increase.

[0005] The active tilting method consists of inclining the body by means of actuators arranged between the bogie and the body, including mechanisms determining the movement of the body by means of said actuators. With this method, better tilt angles with a normal structure of the bogie and of the body are achieved, but the system in itself has a complexity making the design, the construction, the development and the maintenance of the application railway vehicle more expensive.

[0006] In addition, to control active tilting trains, a method is known which defines the tilt angle of the body of the vehicle using acceleration signals taken from the actual vehicle, this technique gives rise to a delay in the tilting, caused by the need to filter the signals and by the response times of the vehicle and of the actuation system.

[0007] Another known method for this purpose is the use of the information corresponding to the track layout and to the position of the railway vehicle thereon, such that based on this data, the automation implemented in the vehicle makes the latter start to tilt before the curves, in order to describe a tilting movement compensating the effect of the centrifugal force. This method requires, where appropriate, high precision for the calculation and implementation of the system, such that any error involves an effect worsening the conditions that are to be corrected.

[0008] In all active tilting trains, the actuators used provide a high complexity, increase the price of the trains, increase the maintenance costs and reduce the reliability levels. In conventional trains, a secondary suspension arrangement by means of pneumatic springs on both sides is used, whereby the height of the body of the vehicle is regulated by means of control valves determining the entrance and exit of air in the pneumatic springs, in order to maintain the height of the body with respect to the bogie, controlling the leveling. Each of these valves incorporates an operating lever and a connecting rod for articulating the operating lever to the bogie or to the body of the vehicle.

[0009] Thus, when traveling in a straight route, the pneumatic springs of the vehicle remain inactive, maintaining the two sides at the same height. But when entering a curve, the body receives a lateral acceleration tending to move it towards the outside of the curve, whereby the suspension is deformed and causes a rolling towards this side of the curve. This effect is what activates the leveling valves, as tilting of the body towards one side of the vehicle makes the connecting rods act over the levers of the valves in an opposite manner on each side of the vehicle, making the pneumatic springs of the side of the vehicle corresponding to the outer part of the curve fill up with more air, whereas the pneumatic springs of the side located towards the inside of the curve expel air, thus causing an action opposite to that caused by the centrifugal force.

[0010] In order for the air consumption of the leveling pneumatic suspension to be low, low-flow leveling valves are usually used, such that the amount of air which is introduced and extracted from the pneumatic springs is reduced, but this makes the response of the pneumatic springs slow and therefore proper height control to effectively correct the rolling in curves is not achieved.

[0011] A better response of the pneumatic springs is achieved with high-flow valves, a better correction of the rolling in curves being obtained. Due to the fact that the valves have a minimum actuation movement, until they effectively cause the entrance or exit of air in the pneumatic springs, the body of the vehicle maintains a certain residual rolling in the balance established along the curves. This residual acceleration added to the deformation of the primary suspension makes the angle of the body be smaller than the banking provided by the track, therefore the lateral acceleration at the level of the body is greater than at the level of the rail.

Object of the Invention

[0012] According to the invention, a railway vehicle is proposed which allows increasing the effect of banking

provided by the track, using the actual conventional pneumatic suspension of the vehicles, without needing to add complex additional elements and without complicating the constructive features of the bogie or of the body of the vehicle. The vehicle object of the invention is based on the arrangement of the control valves for controlling the entrance and exit of air of the pneumatic springs, with their operating lever joined to a connecting rod which is inclined in relation to the perpendicular to the plane of the track. In the application vehicle, the valves of the pneumatic springs can be incorporated on the body of the application railway vehicle, the inclined connecting rods being joined to the bogie of the vehicle. Another solution is to arrange the valves on the bogie and the inclined connecting rods joined to the body, the functional result being equivalent.

[0013] An arrangement is thus obtained whereby the movement of the body due to the inertial forces in curves makes the connecting rods cause an operation of the levers joined to the valves. Air thus enters the springs corresponding to the outer part of the curve, and air exits the springs corresponding to the inner part of the curve, compensating the natural inclination of the body and reducing the lateral acceleration that the passenger feels. Said action is the result of the actuation on the valves with an intensified effect due to the inclined position of the connecting rods, whereby a faster and more intense actions is achieved than with conventional arrangements, and as a result the correction of the tilting of the body is completely effective.

[0014] To establish a limitation of the movement of the pneumatic springs in the rolling action of the body of the application railway vehicle, the arrangement of stops limiting the rotation of the lever of the control valves of the mentioned pneumatic springs is provided. The connecting rods which are joined to said levers of the valves are arranged with a structure which is flexible in a longitudinal direction to absorb the overstress forces.

[0015] Due to the foregoing, the system of the invention has truly advantageous features, acquiring its own identity and a preferred character compared to conventional systems of the same application.

Description of the Drawings

[0016]

Figure 1 shows a diagram of the conventional arrangement of the suspension of a railway vehicle, in the normal position of traveling in a straight route.

Figure 2 shows the same previous diagram in the position of natural inclination of the body of the vehicle due to the inertia in a curve.

Figure 3 shows the previous diagram in a position of partial recovery of the inclination of the body.

Figure 4 is a diagram of the arrangement of the suspension of a tilting railway vehicle, according to the system of the invention, according to a depiction of the operation of the system in a straight route.

Figure 5 is a depiction of said suspension according to the system of the invention when entering a curve.

Figure 6 is a depiction of said suspension according to the system of the invention when rounding a curve.

Figure 7 is a detail of a practical embodiment of a connecting rod which is flexible in a longitudinal direction.

Detailed Description of the Invention

[0017] The object of the invention relates to a tilt control system for railway vehicles, proposing an arrangement which allows reducing the lateral acceleration that the passenger feels due to the inertial force and thus proposing better conditions for traveling over curves.

[0018] Railway vehicles usually have a secondary suspension by means of pneumatic springs (1) included between the bogie (2) carrying the running gear and the body (3) of the vehicle, incorporating valves (4) controlling the entrance and exit of air of the mentioned pneumatic springs (1). Said valves (4) have three functional positions, in one of which they connect the corresponding pneumatic spring (1) with an air supply system. In the other position, they cut off the entrance and exit of air of the pneumatic spring (1), and in the third position, they open up the exit of air of the pneumatic spring (1) to the atmosphere.

[0019] The mentioned valves (4) have an operating lever (5) for changing the functional positions. Said valves (4) can be assembled both in the body (3) and in the bogie (2), obtaining the same operation in the two cases. In the first case, the lever (5) of the valve (4) is articulated to the bogie (2) by means of a connecting rod (6). In the second case, the connecting rod (6) joins the lever (5) of the valve (4) assembled in the bogie (2) to the body (3).

[0020] In these conditions, when traveling in a straight route, the body (3) of the vehicle is maintained leveled in a horizontal position, as depicted in Figure 1, the valves (4) maintaining the entrance and exit of air of the pneumatic springs (1) closed, which springs in this situation are balanced without modifying their amount of air.

[0021] However, when the vehicle enters a curve, depending on the speed and on the radius of the curve, the body (3) of the vehicle undergoes a lateral acceleration, a rolling being caused which causes the side of the body (3) outside the curve to tend to move down and the inside one on the other hand to move up, as depicted in Figure 2.

[0022] Said rolling of the body (3) makes the connecting rods (6) act on the levers (5) of the valves (4), in an opposite manner in both sides of the vehicle. Therefore, the valves (4) of the side corresponding to the outside of the curve open up the entrance of air to the pneumatic springs (1) of this side, whereas the valves (4) of the side corresponding to the inside of the curve open up the exit of air of the pneumatic springs (1) of this side.

[0023] Thus, the pneumatic springs (1) corresponding to the side of the outer part of the curve exert an upward

thrust action, in the direction of elevation of the body (3) on this side, whereas the pneumatic springs (1) corresponding to the inner part of the curve, yield, tending to allow the body (3) to move down on this side, whereby there is a combined effect of the suspension in opposite directions on both sides, which makes the body (3) tend to the horizontal leveling against the effect caused by inertia.

[0024] However, given that the valves (4) have a certain movement until their action is effective, with the conventional arrangement of the connecting rods (6) in a vertical position, the action is not enough, a residual inclination of the body (3), which takes a long time to recover, being maintained, therefore a small rolling is maintained in the movement over the curves, as depicted in Figure 3.

[0025] According to the invention, the arrangement of the connecting rods (6) which are joined to the operating levers (5) of the valves (4) controlling the filling and emptying of the pneumatic springs (1) is established in an inclined position in relation to the perpendicular to the plane of the track, as depicted in Figure 4, which shows the behavior of the system when traveling on a straight route.

[0026] Therefore, when the application railway vehicle enters a curve (Figure 5), the lateral acceleration due to the inertial forces makes the body (3) move and incline towards the outer part of the curve, such that due to its inclination the connecting rods (6) cause an operation of the valves (4) which means a response against said effect of inertia, but furthermore, due to the lateral movement of the body, the inclined position of the connecting rods (6) causes a complementary effect of operation on the valves (4), determining that the action thereof is intense enough for the response of the pneumatic springs (1) to immediately cause (Figure 6) a tilt angle of the body (3) increasing the effect of banking provided by the track, until a value which can be chosen depending on the geometric features of the connecting rods (6) and the operating levers (5) of the valves (4).

[0027] To limit the movement of the pneumatic springs (1), so that their action only affects a certain degree of inclination of the body (3), within safety limits, the arrangement of stops (7) limiting the movement of the operating lever (5) of the valves is provided. In this case, connecting rods (6) which are structurally flexible in the longitudinal direction are provided to prevent forces which can cause harmful stress, for example according to the embodiment depicted in Figure 7, which is not limiting.

[0028] In the practical embodiment of the application assembly, it is further provided that the functional elements of the system are protected by a cover (not shown) to prevent accumulations of dirt which can cause malfunction.

Claims

1. A railway vehicle comprising a bogie (2), a body (3), a suspension by means of pneumatic springs (1) arranged between the bogie (2) and the body (3), at each side of the railway vehicle, and a tilt control system comprising valves (4) for controlling the filling and emptying of said pneumatic springs (1) to cause an inclination of the body (3) with respect to the plane of the track, each of the valves (4) being mounted on one of the bogie (2) or the body (3) and incorporating an operating lever (5) and a connecting rod (6) articulating the operating lever (5) to the other of the bogie (2) or the body (3), so that tilting of the body (3) towards one side of the vehicle makes the connecting rods (6) act over the levers (5) of the valves (4) in an opposite manner on each side of the vehicle, causing the pneumatic springs (1) of the side towards which the body (3) tilts to fill up with air and the pneumatic springs (1) on the opposite side to empty, and **characterized in that**, on a straight route, the connecting rod (6) associated to each operating lever (5) is inclined with respect to the perpendicular to the plane of the track, so that said inclined connecting rods (6) determine a combined response of operation of the valves (4) due to both the inclination and the lateral movement of the body (3) caused by the inertial forces generated in curves.

2. The railway vehicle according to claim 1, **characterized in that** it comprises stops (7) in relation to the movement of the operating lever (5) of the valves (4), by means of which stops (7) a limitation of the movement of the pneumatic springs (1) in the tilting of the application body (3) is determined, the connecting rods (6) being arranged with a structure which is flexible in the longitudinal direction to prevent overstress as a result of the stops (7).

Patentansprüche

1. Schienenfahrzeug, umfassend ein Drehgestell (2), einen Wagenkasten (3), eine Aufhängung mittels Luftfedern (1), die zwischen dem Drehgestell (2) und dem Wagenkasten (3) auf jeder Seite des Schienenfahrzeugs angeordnet sind, und ein Neigungssteuersystem, das Ventile (4) umfasst, um das Befüllen und Entleeren der Luftfedern (1) zu steuern, um eine Neigung des Wagenkastens (3) in Bezug auf die Gleisebene zu bewirken, wobei jedes der Ventile (4) entweder an dem Drehgestell (2) oder dem Wagenkasten (3) montiert ist und einen Bedienhebel (5) und einen Verbindungsstange (6) enthält, die den Bedienhebel (5) an dem anderen des Drehgestells (2) und des Wagenkastens (3) anlenkt, so dass das Neigen des Wagenkastens (3) in Richtung einer Seite des Fahrzeugs die Verbindungsstangen (6) ver-

anlasst, über die Hebel (5) der Ventile (4) in einer entgegengesetzten Weise auf jeder Seite des Fahrzeugs zu wirken, was bewirkt, dass sich die Luftfedern (1) der Seite, zu der sich der Wagenkasten (3) neigt, mit Luft füllen, und sich die Luftfedern (1) auf der gegenüberliegenden Seite entleeren, und **dadurch gekennzeichnet dass**, auf gerader Strecke, die jedem Bedienhebel (5) zugeordnete Verbindungsstange (6) in Bezug auf die Senkrechte der Ebene des Gleises so geneigt ist, dass die geneigten Verbindungsstangen (6) ein kombiniertes Betriebsverhalten der Ventile (4) sowohl aufgrund der Neigung als auch der Lateralbewegung des Wagenkastens (3), die durch die in Kurven erzeugten Trägheitskräfte verursacht wird, bestimmen.

2. Schienenfahrzeug nach Anspruch 1, **dadurch gekennzeichnet, dass** es Endanschläge (7) für die Bewegung des Bedienhebels (5) der Ventile (4) umfasst, wobei mittels der Endanschläge (7) eine Begrenzung der Bewegung der Luftfedern (1) beim Neigen des belasteten Wagenkastens (3) bestimmt wird, wobei die Verbindungsstangen (6) mit einer Struktur versehen sind, die in der Längsrichtung flexibel ist, um eine Überbelastung infolge der Endanschläge (7) zu vermeiden.

Revendications

1. Véhicule ferroviaire comprenant un bogie (2), un corps (3), une suspension au moyen de ressorts pneumatiques (1) agencée entre le bogie (2) et le corps (3), de chaque côté du véhicule ferroviaire, et un système de commande d'inclinaison comprenant des soupapes (4) pour commander le remplissage et le vidage desdits ressorts pneumatiques (1) pour provoquer une inclinaison du corps (3) par rapport au plan de la voie, chacune des soupapes (4) étant montée sur l'un parmi le bogie (2) ou le corps (3) et comprenant un levier de commande (5) et une bielle (6) articulant le levier de commande (5) sur l'autre parmi le bogie (2) ou le corps (3), de sorte que l'inclinaison du corps (3) vers un côté du véhicule permet aux bielles (6) d'agir sur les leviers (5) des soupapes (4) d'une manière opposée de chaque côté du véhicule, amenant les ressorts pneumatiques (1) du côté vers lequel le corps (3) s'incline, à se remplir d'air et les ressorts pneumatiques (1) du côté opposé à se vider, et **caractérisé en ce que**, sur un itinéraire droit, la bielle (6) associée à chaque levier de commande (5) est inclinée par rapport à la perpendiculaire au plan de la voie, de sorte que lesdites bielles (6) inclinées déterminent une réponse de commande combinée des soupapes (4) due à la fois à l'inclinaison et au mouvement latéral du corps (3) provoqué par les forces inertielles générées dans les virages.

2. Véhicule ferroviaire selon la revendication 1, **caractérisé en ce qu'**il comprend des butées (7) par rapport au mouvement du levier de commande (5) des soupapes (4), au moyen desquelles butées (7), une limitation du mouvement des ressorts pneumatiques (1) dans l'inclinaison du corps d'application (3) est déterminée, les bielles (6) étant agencées avec une structure qui est flexible dans la direction longitudinale pour empêcher une surtension en raison des butées (7).

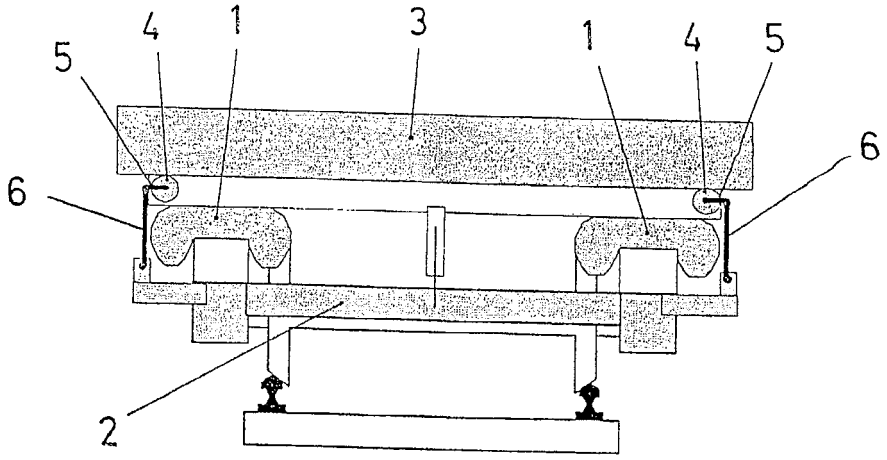


Fig.1

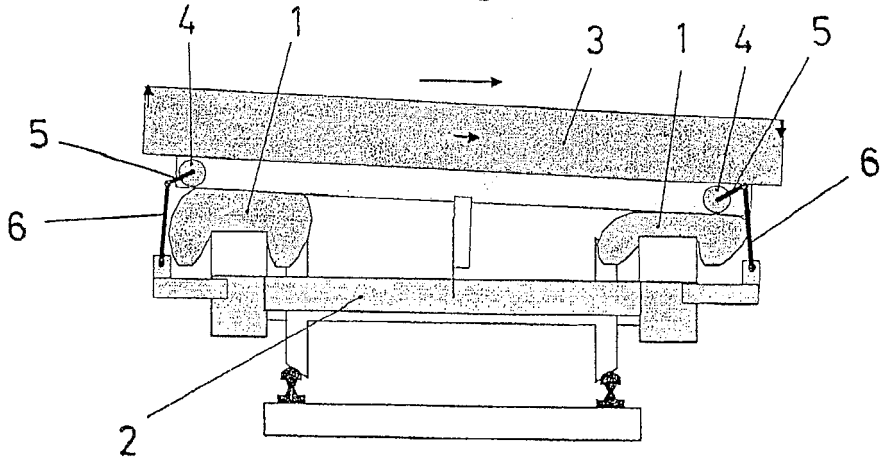


Fig.2

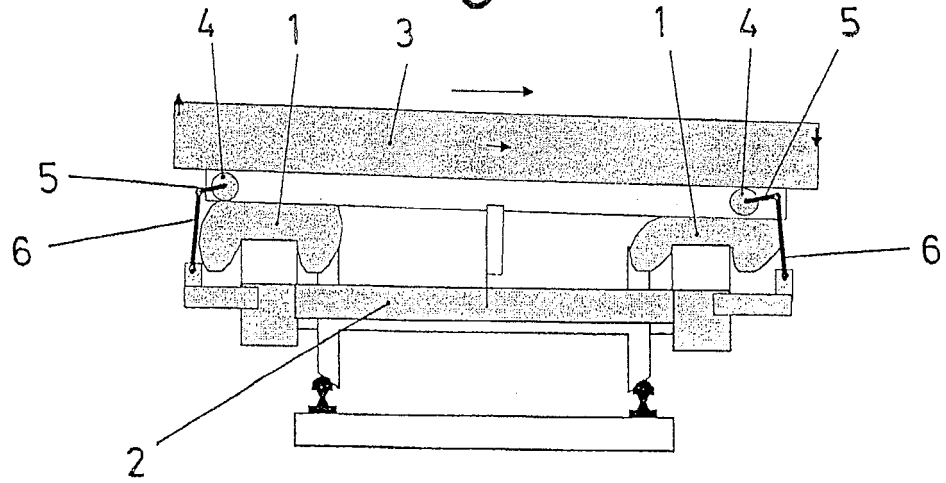


Fig.3

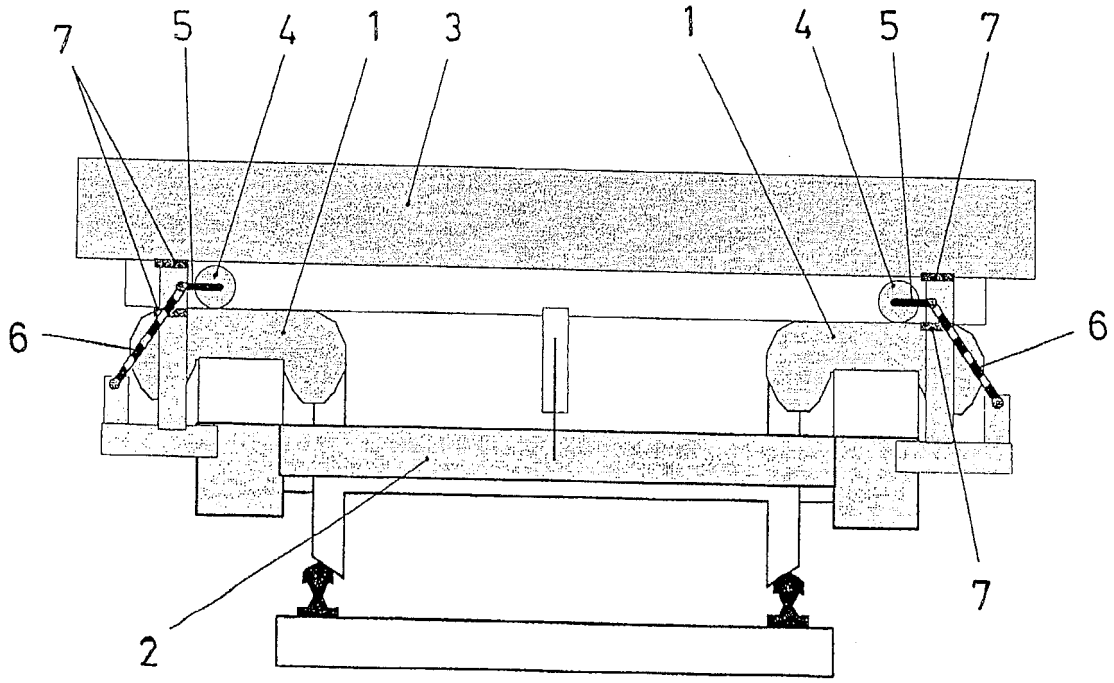


Fig. 4

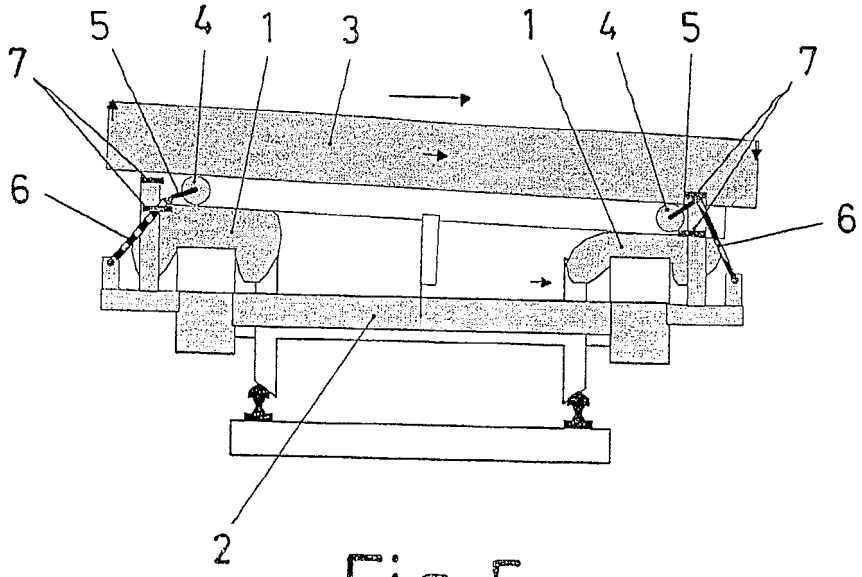


Fig. 5

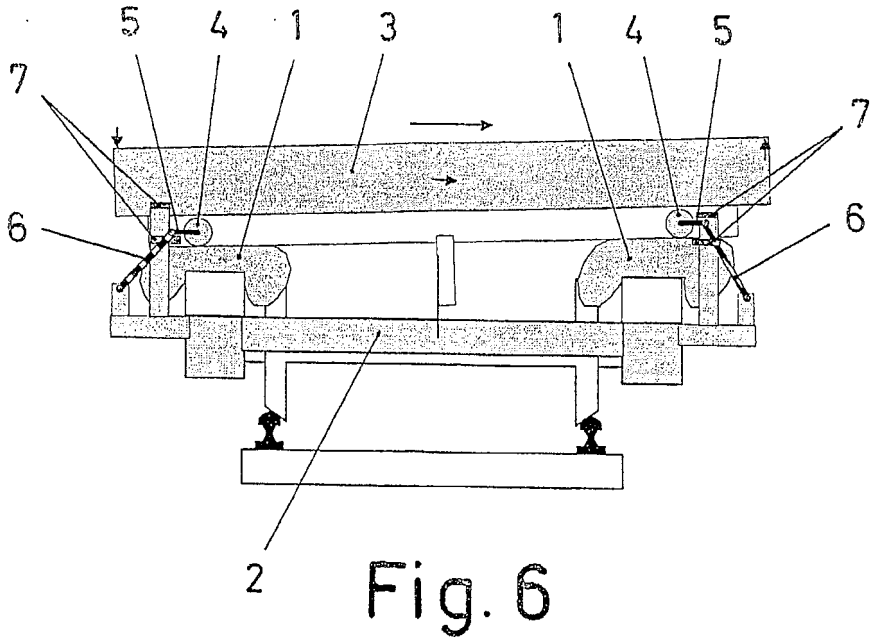


Fig. 6

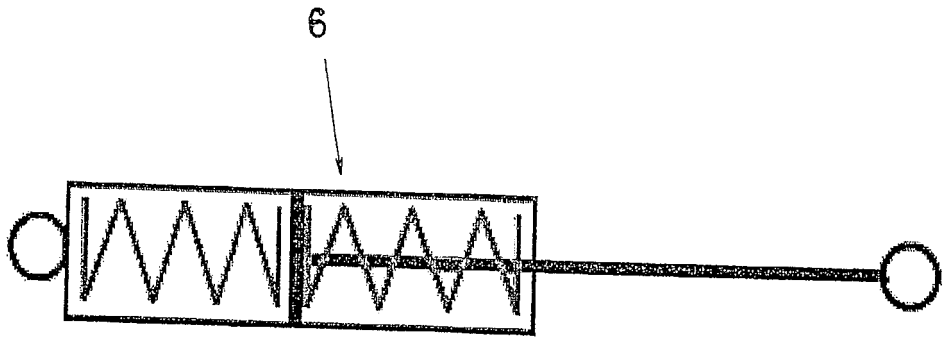


Fig. 7